DEVELOPMENT AND FUTURE TRENDS IN BUNKER STORAGE

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ABSTRACT

The Grain Handling Authority of N.S.W. has developed a system of bunker-type storage that was originally envisaged as an extension of the technique of temporary storage. This has now reached the stage where it is a satisfactory form of permanent storage where only minimal capital requirements are warranted, where capital is simply not available for the construction of storages, or where a storage facility must be provided at very short notice.

The PVC-covered bulk grain storage system is capable of directly responding to two of the current needs of bulk handling organizations: the need to minimise handling and storage costs, and the need to control insect infestation in grain without the use of chemical protectants and, possibly, without the use of fumigants. These storages are now routinely being constructed to 50,000 tonne capacity, and feature movable concrete banks and bitumen surface. A range of portable grain handling equipment has been designed to complete the new storage and handling system. The operational problems encountered in bunker storages include grain contamination with earth, damage to the covers and difficulties with grain receival under some conditions. All these problems have been overcome or reduced to a low level.

A major advantage of the PVC bunker-type storage is that it can be fumigated satisfactorily with phosphine. This treatment is a very cheap form of fumigation and experience to date indicates that the storages are sufficiently gastight to render it completely effective.

Grain storage in bunker systems is now substantially cheaper than in permanent structures (e.g. steel bins $20 per tonne capacity, bunkers ca. $8 per tonne capacity per annum, including handling and capital charges).

INTRODUCTION

With wheat farming pushing further and further into hitherto marginal country, some bulk grain handling organizations in Australia will find it necessary to provide extensive storage capacity in areas where harvests fluctuate widely from season to season and where in some seasons there may be no crops at all. Other organizations may face the need to store an increased crop, but have access to only limited capital funds. In these circumstances there can be no justification for a high level of capital investment as, with the exception of the labour requirement, all the basic requirements of storage can now be met by the use of low cost bunker-type storage, as developed in New South Wales in recent years.

BACKGROUND - GRAIN HANDLING AUTHORITY OF N.S.W

Role of the N.S.W. Grain Handling Authority

In Australia, the primary role of State bulk handling authorities is to act as the agents of the Australian Wheat Board for the receival, storage, preservation and handling of wheat. The operations of each authority include:

- provision and maintenance of a country elevator system and terminal facilities for the storage and handling of grain;
- provision of labour to operate the elevator system;
- arrangements for the segregation of different grades of wheat and other grains in the elevator system;
- arrangements to control pest infestation of wheat in storage;
- receival of wheat, by quantity and grade as specified by the Australian Wheat Board, and arrangements for the transportation of wheat consignments to destinations nominated by the Australian Wheat Board.

Development of the N.S.W. Grain Storage System

Wheat was first received at country silos in the 1920/21 season, when total receivals amounted to 52,844 tonnes from a crop of 1,513,865 tonnes. Record New South Wales wheat crops since the 1920's are given in Table 1.

Table 1
Record wheat tonnages in N.S.W.

Season	Total crop (tonnes)
1932/33	2.1m
1947/48	2.6m
1962/63	3.0m
1963/64	3.3m
1964/65	4.1m
1966/67	5.5m
1968/69	5.8m
1978/79	6.5m

The development of our bulk storage system is summarised in Table 2.

Table 2
Storage Capacity in the N.S.W. bulk handling authority system

Period (approx.)	Total capacity available at end of period (tonnes)
1918–1920	332,030
1921-1936	796,681
1937–1942	892,071
1943–1950	897,514
1951-1960	1,981,204
1961-1965	2,616,823
1966	2,775,762
1967	3,161,951
1968	3,614,001
1969	4,412,505
1970	5,293,744
1971	5,705,651
1972–1973	5,764,981
1973–1974	5,783,100
1974–1976	5,829,000
1976–1977	5,855,400
1977–1978	5,854,400
1978–1979	5,966,750

Table 2 clearly reflects the accelerated rate at which the storage system expanded over the period from 1951 to 1970. It is interesting to note that when silo construction was interrupted by World War II the total capacity, including terminal elevators, stood at approximately 847,029 tonnes. In fairness to the authorities of the time, however, it must be stated that the need for bulk handling facilities was much less pressing than it became in the post-war years. Many farmers, in fact, preferred to deliver their wheat to bag stacks. Pre-war, moreover, the production of wheat in New South Wales had never reached 2.15 million tonnes.

During the 1960s, as record crop succeeded record crop (Table 1), the demand for bulk storage facilities accelerated. Considerable strain was thrown upon the resources of the system. Despite the enormous amount of storage built from 1961 onwards, the increase in wheat production continued to out-strip that of the capacity of the elevator system, except in the drought years 1965/66 and 1967/68. The storage lag was not finally overcome until 1969/70. The total space available for the 1969/70 season was slightly greater than the record delivery of the preceding season.

One can appreciate the physical pressures exerted at the point of receival, reflected in a constant flood of telegrams and telephone calls to Head Office asking for, or demanding, rail trucks to make space for futher receivals. Nowadays such telegrams are quite rare. Very long queues were once a familiar sight at country plants, often lasting for weeks on end. Even when space was available the queues at some plants were so lengthy that farmers managed to deliver only one load per day, or sometimes one load in two or three days. Wealthier or more enterprising farmers countered by hiring several carriers so as to have a number of loads in the queue at one time.

Another practice was to listen to early morning broadcasts concerning truck placements or watch to see where rail trucks were being placed for loading. In the days before some form of zoning was introduced, farmers' deliveries were unrestricted. They could thus move their vehicle from one queue to another in pursuit of space, and it was not uncommon for wheat to be carted distances of up to one hundred and sixty kilometres.

With the exception of a very small number of temporary bulkheads, all storage built up to 1950 was in the form of orthodox vertical silos. From then until very recently, storage in horizontal sheds predominated; so much so that of the total capacity of almost six million tonnes, only 25% is vertical storage. In recent years, permanent storage expansion has been in the form of vertical cells and other storage in the form of large PVC-covered bunker storages. We now have about 480 country elevators (including sub-terminals) and a growing number of bunkers, ranging in capacity from 800 tonnes to 60,000 tonnes. A large bunker storage is shown in Figure 1. These storages are located at approximately 270 centres. Handling rates vary from 50 tonnes per hour to 400 tonnes per hour.

THE BUNKER-TYPE STORAGE

Application

The Grain Handling Authority of N.S.W. has developed a system of bunker-type storage. The system was originally envisaged purely as temporary storage but has now been developed to a stage where it is a satisfactory form of permanent storage. It is particularly appropriate where only minimal capital requirements are warranted, where capital is simply not available for the construction of storages and where a storage facility must be provided at very short notice. In the 1978/79 harvest, 200,000 tonnes of grain was stored in bunker-type storages, and in the 1979/80 harvest approximately 1.5 million tonnes of grain was stored in this fashion.

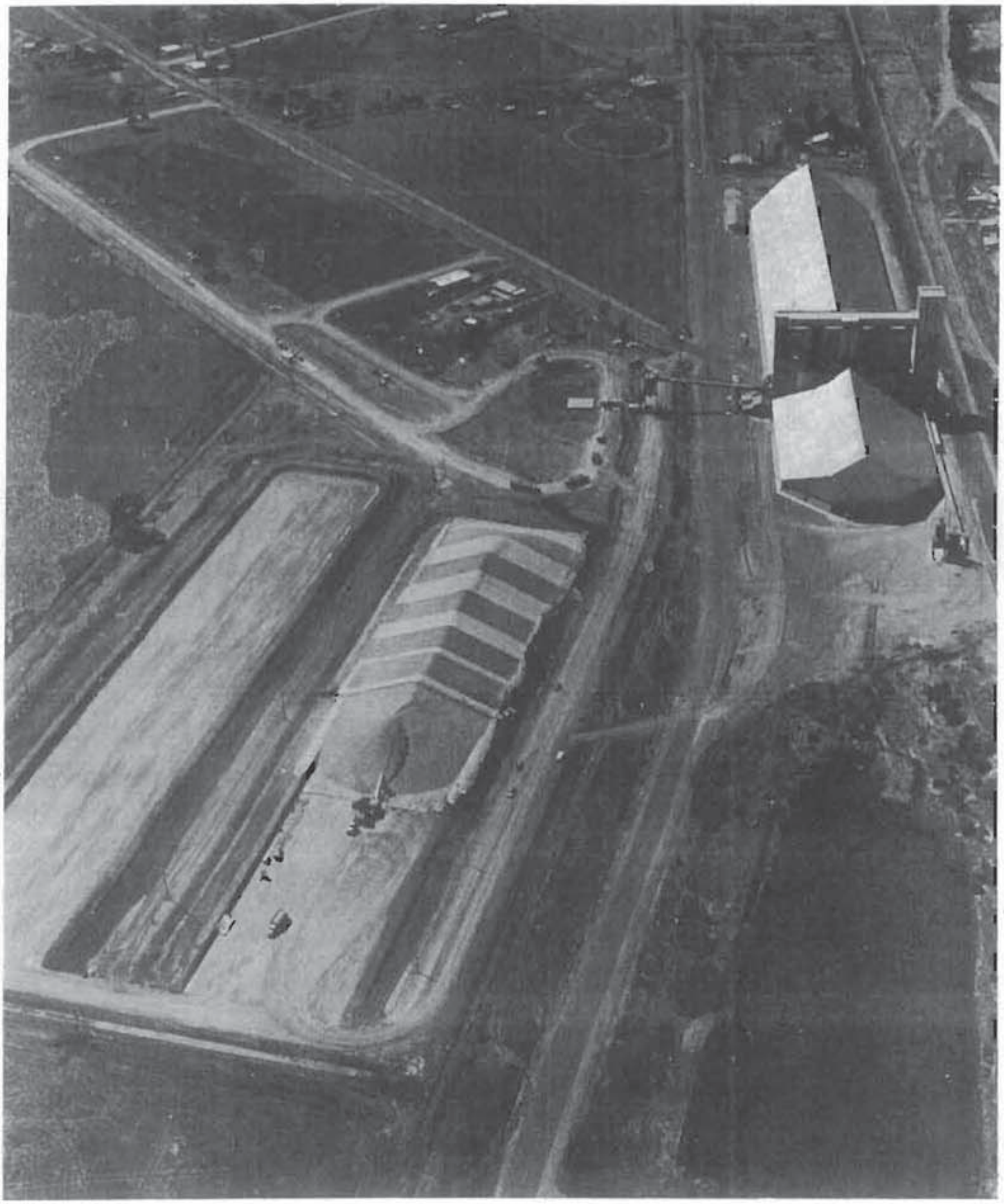

Fig. 1. Bunker storages at Junee, N.S.W., being filled with wheat.

Development

This new bunker-type storage evolved from an earlier concept of underground storage, now greatly modified with assistance from commercial suppliers of materials and equipment to make it more efficient operationally and more economic.

Some years ago, the Commonwealth Scientific and Industrial Research Organisation (CSIRO), in collaboration with the Authority, put down an experimental underground storage in the northwest of New South Wales. The trial was designed to provide medium to long-term storage for grain at a relatively low cost, and was undertaken in anticipation that the storage provided would obviate any problems of insect infestation. The store was entirely underground. A pit was excavated and filled with wheat and then covered with a thin PVC-cover and then with soil. Undoubtedly, in certain soil types and selected positions, this type of storage does provide a solution to the problem of long-term storage where permanent storage facilities are not available, but it was found to be highly labour-intensive and to involve working conditions which are very severe. The earth covering presented particular problems. A further trial in conjunction with the CSIRO involved the provision of an above-ground storage covered by sand and earth. This used an earth-walled bunker with a PVC cover on which approximately a metre of covering soil was placed. This type of storage has been used quite extensively in Victoria, but the use of the earth cover is now discontinued.

While it was an improvement on the underground storage, the earth covering in particular presented appreciable operational problems. Having regard to the availability of high-quality PVC materials, the Grain Handling Authority of N.S.W. took the view that an earth covering was not necessary. It was considered that storages could be made more cheaply and in an operationally superior manner by covering the grain with a heavy-duty, high-quality PVC material.

The Authority carried out a trial of this system in 1977 which was relatively satisfactory. Further trials were planned, but a heavy demand for additional temporary storage in the 1978/79 season necessitated immediate and relatively large-scale use of this type of temporary storage. The need increased still further in the 1979/80 season, when 1.5 million tonnes of wheat was placed in this type of storage.

Operational Problems Encountered

While a number of problems were experienced in the earlier stages, all of the serious problems which can be resolved have been resolved although a few minor ones remain.

Problems which have been experienced included:

a. Admixture of some earth with the grain.

b. Admixture of stones with the grain.

c. Damage to PVC material from various causes, including birds and hail.

d. Failure of adhesive, allowing PVC sheets to come apart.

e. Inability to receive into storages in high wind.

f. Vandalism of storages which were not protected by fences.

g. Rain during inloading and outloading.

With respect to (a), admixture of earth with grain, the problem still exists where earth banks are used, although it has been, in all but a few instances, quite minor. Provision of concrete banks rather than earth banks and the sealing of the storage floor surface with asphalt completely eliminates the problem and also (b), the admixture of stones. A solid asphalt base was also found suited to direct tipping from growers' vehicles, greatly assisting the rate of receival into the new type of storage.

The problem of hail damage, (c), still remains. What might be termed normal hail does little or no damage. It is only when large, jagged hail falls that serious damage occurs. The authority has had bunker storages at 96 different sites (with several bunkers at some sites) over the past few years and only one bunker has been seriously damaged by hail. In this case, no significant damage occurred to the grain but there was considerable work involved in repairing the PVC cover. However, the incidence of such damage over a number of sites is very small and, while it cannot be ignored, it can be easily coped with, providing adequate inspection of storages is maintained.

The problem of the failure of the adhesive used on the PVC has now been overcome by sewing the sheets together rather than using a sealant. This also obviates the need to clean the used PVC sheets as thoroughly as was necessary when an adhesive was relied on. A bag-sewing machine, preferably one that provides a lock-stitch so that there is virtually no possibility of the stitch coming undone and allowing the sheets to part, is used to sew the sheets. It is only fairly recently that stitching has been adopted but it appears to have been completely satisfactory. A sealant is provided over the stitching to ensure gas-tightness.

Inability to receive into storages in high wind remains a problem, although the new grain throwing machines referred to below (Section 4) can be used in moderate wind, depending, to some extent at least, on the direction of the wind. The ideal loading machine would be one which is not influenced by wind and there is no reason to believe that such a machine cannot be designed in the future.

In respect to (f), vandalism should be almost completely eliminated if good, solid "man-proof" fences are erected around each storage. Such fences are also a necessity if storages are to be fumigated.

Fumigation

In the 1978/79 harvest, grain loaded into bunker storages was treated with fenitrothion (12 mg/kg^{-1}) and bioresmethrin (1 mg/kg^{-1}) for protection against stored products pests. However, in the 1979/80 harvest, approximately 250,000 tonnes of grain loaded into bunker storages was not treated with any chemicals at all, whereas the remaining quantity was treated with fenitrothion (12 mg/kg^{-1}) only. This decision was made because of the lack of sufficient bioresmethrin from commercial sources and the successful fumigation of a 10,000 tonne bunker storage at Grenfell in September, 1979 with phosphine-generating sachets manufactured by 'Detia' of West Berlin (Banks and Sticka 1981).

In the trial at Grenfell, aluminium phosphide sachets in the form of a blanket (30 cm wide x 4.6m long, containing 100 x 34g sachets, each liberating 11g of phosphine) were placed on top of the grain mass below the plastic covering. This trial demonstrated that phosphine fumigation of PVC-covered bunker storage was feasible commercially, and gave data on the dosage of phosphine required.

Further trials (Banks and Sticka 1981) were carried out in the PVC bunker storages at Grenfell in March 1980 using phosphine-generating 'plates' of both aluminium and magnesium phosphide as supplied by 'Degesch' of West Germany. Representatives of 'Degesch' were present and assisted in the initiation of these trials.

Commercial fumigation of the 1.5 million tonnes of grain placed in bunker storages during the 1979 harvest intake throughout New South Wales was commenced on 7th January, 1980 and has continued since the completion of the harvest intake.

The Grenfell trial, which was intensively monitored, and subsequent extensive commercial use of the phosphine-generating blanket have demonstrated that this fumigation technique can be applied easily to PVC-covered bunker storages as constructed in New South Wales. It has been shown that these storages are sufficiently gas-tight to retain phosphine for long periods, thus allowing natural gas movements to distribute the gas throughout the bulk. Futhermore, the length of time that phosphine is retained is sufficiently long for even a low concentration of phosphine to be effective. The levels of phosphine gas obtained are generally sufficient to give a product substantially greater than that necessary for complete insect kill. It is only necessary to carry out minimal gas monitoring during fumigation, and the treatments conducted to date have all given consistent and satisfactory results.

Whilst the blanket technique is simple to use, careful attention must be given to ensure that enclosures are well sealed. Because of slow and continuing evolution of phosphine gas from blankets, fumigated stacks should not be moved for about 30 days after fumigation. In general, this delay should not create any operational problems and, from a pest control point of view, the evolution of phosphine gas is advantageous in maintaining the overall phosphine concentration for sufficient time to ensure adequate distribution of the gas within the bulk, despite the small, but significant, loss rate.

GRAIN HANDLING SYSTEMS FOR BUNKER STORAGES

To place the grain into the storage requires a mobile throwing machine which throws the grain to the height required and can be retracted as the length of the storage grows. When the large storages were conceived, it was realised that, with existing equipment and procedures, it would take 100 days to inload and another 100 days to outload a 60,000 tonne storage. A new thrower was developed which could place 250 tonnes in an hour, or with 2 machines, place 5,000 tonnes in a day. Two 50,000 tonne storages can then be filled in 20 days. The throwing height was increased from 7.5 metres to 11 metres with this new machine. The same machine outloads at 200 tonnes in an hour or 2,000 tonnes in a day. This machine, which we call a 'Lobstar' (Fig. 2), represents a major step forward in handling large bulks of grain in open positions. The Authority now has about 40 Lobstars, half of which are electric-powered and half diesel-powered.

While labour costs for this type of storage had at first appeared to be high, the capital investment was very low. Provided a fast receival system could be coupled together with a good outloading system, the total scheme could be very cost effective. Development effort thus began to centre on high-capacity portable equipment to suit the new bunker storages.

New modifications to the highly successful Lobstar were developed, greatly improving the versatility of this machine such that the unit could be positioned to load grain directly into rail wagons (Fig. 3). Rail outloading capacity could now be flexible, and could be positioned with most effect in co-ordination with the State Rail Authority's train program. Large front-end loaders with specially designed wheat buckets were obtained to work in with the Lobstars. Special tractor attachments minimise labour needs on the new storage sites.

Dealing with the road truck traffic at bulk sites, new methods of marshalling traffic were developed using traffic lights, modern streamlined sampling stands that handle four vehicles at a time, and multiple weighbridges.

The design of these bunkers was greatly improved. Large 50,000 tonne bunkers are routinely being constructed with movable concrete walls, and a solid asphalt base to permit direct tipping of growers' vehicles. New methods of PVC tarp handling using cables and capstan have minimised the labour requirements to place these large covers.

With the successful development and introduction of these "building blocks", the Authority has now laid down the basis for a new and highly cost-effective grain handling system.

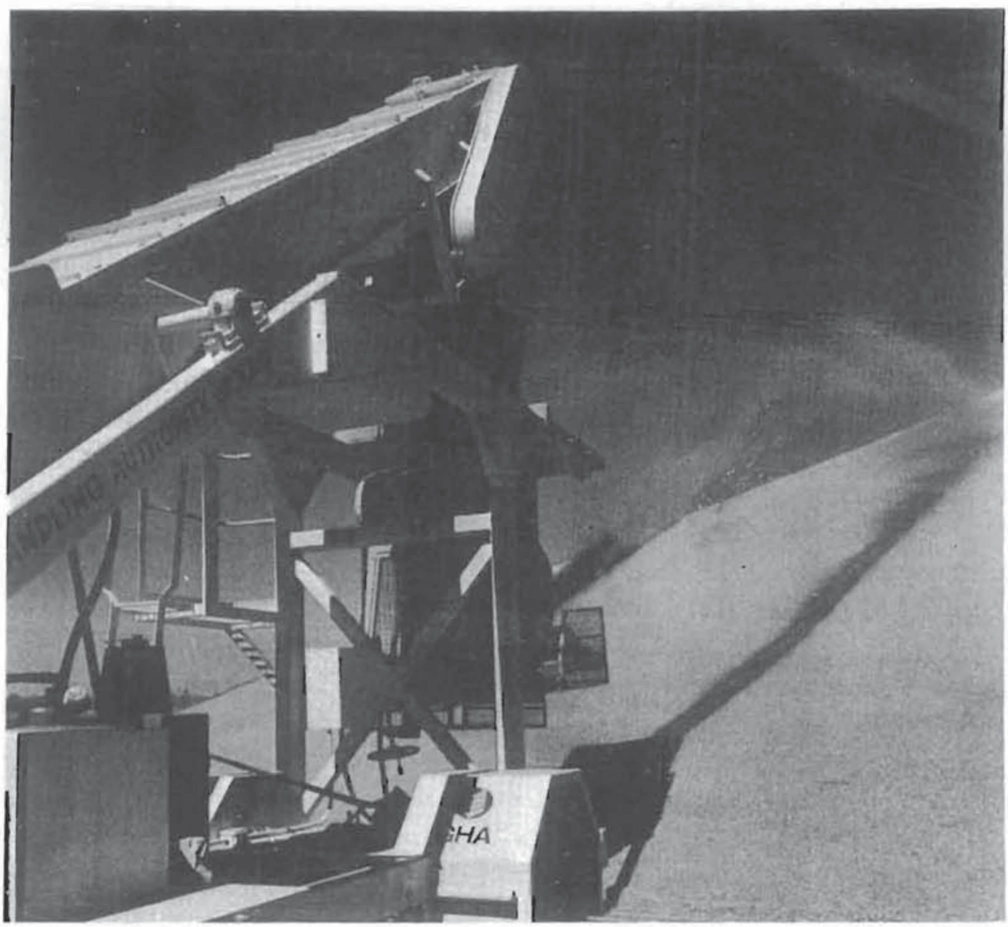

Fig. 2. A G.H.A. designed 'Lobstar' grain thrower loading wheat into a temporary storage.

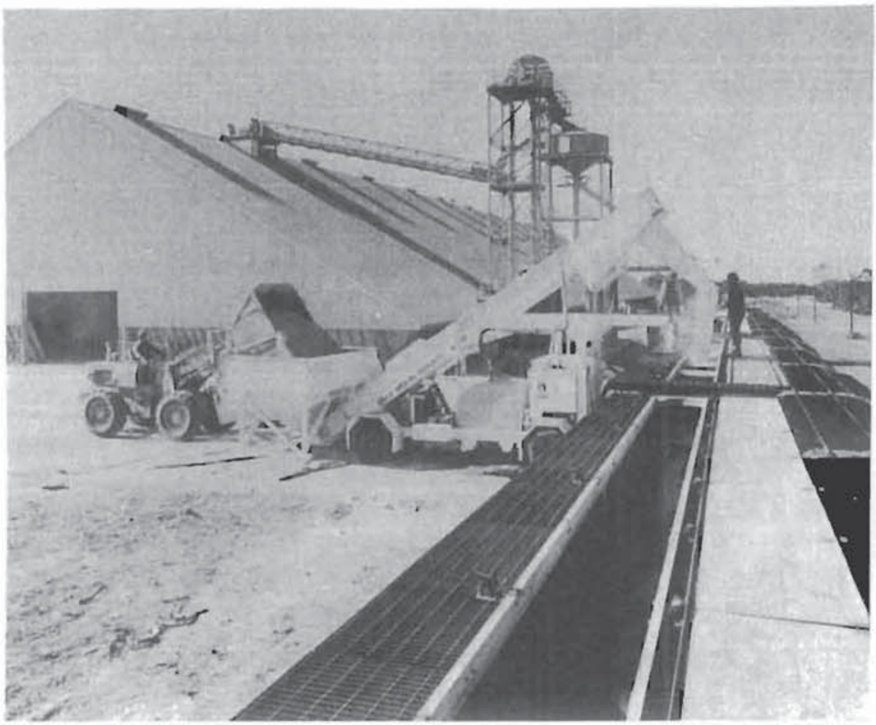

Fig. 3. Loading direct to rail with a modified 'Lobstar' at Wyalong, N.S.W.

COSTS OF BUNKER STORAGE

While further work needs to be done in respect to the costing of different types of storage and its utilisation, there is increasing evidence that the bunker-type storage now in use may be more economical to use, taking account of all costs--capital and operating, than traditional storage designs.

For example, a PVC bunker-type storage of approximately 30,000 tonnes capacity would cost A$7.82 per tonne to utilise, including all costs of inloading and outloading, if the storage is used annually. However, the equivalent costs of storage in steel bins erected at present costs would amount to at least A$20 per tonne capacity including capital charges and amortisation.

CONCLUSION

The storage, handling and fumigation techniques which have been outlined, using PVC-covered bunker storages, have provided the basis for a completely new grain handling system in New South Wales. The system is not only very economic, but offers a degree of flexibility in grain handling which is well matched to the fluctuating demands placed upon a bulk handling authority.

REFERENCE

Banks, H.J. and Sticka, R. (1981). Phosphine fumigation of PVC-covered, earth-walled bulk grain storages: full scale trials using a surface application technique. CSIRO Aust. Div. Entomol. Tech. Pap. No. 18., 45pp.